KING COUNTY CONVEYANCE SYSTEM IMPROVEMENT PROJECT

TASK 260

HIDDEN LAKE SERVICE AREA TASK SUMMARY REPORT

Hidden Lake Service Area
Task 260: Task Summary Report

Table of Contents

List of Tables

LIST OF FIGURES

KING COUNTY CONVEYANCE SYSTEM IMPROVEMENT PROJECT
HIDDEN LAKE SERVICE AREA TASK SUMMARY

This Task 260 report summarizes the Conveyance System Improvement (CSI) Project team's work in the Hidden Lake Service Area[1] (Service Area) and outlines recommended alternatives for addressing wastewater conveyance issues in the Service Area. Specifically, this report describes the Hidden Lake Service Area and summarizes its planning history. The report then describes the wastewater facilities that presently serve the area, and identifies existing capacity limitations and mechanical problems. The report then summarizes the alternatives developed and analyzed to identify a working alternative for relieving capacity and mechanical problems. Constraints to capacity improvements posed by the area's natural and physical environment are also noted.

TASK 210: HIDDEN LAKE SERVICE AREA PLANNING HISTORY

The Hidden Lake Service Area is located in northwest King County in the City of Shoreline (Figure 1). The Service Area includes areas draining to the Hidden Lake Pump Station and all areas contributing to wastewater flows in the King County conveyance system upstream of the Richmond Beach Pump Station (Figure 2). The King County Wastewater Treatment Division (WTD), Shoreline Wastewater Management District (WMD), and Highlands Sewer District (SD) each own and maintain elements of the wastewater conveyance system within the Service Area.

The Hidden Lake Pump Station has a documented firm pumping capacity of 4.2 mgd, but under actual operating conditions the capacity is 3.8 mgd. An 18-inch diameter overflow line leads to Shoreline WMD Pump Station 4, where wastewater can be temporarily stored, pumped back to the Hidden Lake Pump Station, or discharged 365 feet to Puget Sound via a marine outfall. The Hidden Lake Pump Station discharges to a 2,375-foot, long 14-inch diameter force main section of the Boeing Creek Trunk and then by gravity to the Richmond Beach Pump Station. There are numerous connections from Shoreline WMD sewers to the gravity section of the Boeing Creek Trunk, adding flows to the system downstream of the Hidden Lake Pump Station. From the Richmond Beach Pump Station, flow is pumped to the Edmonds Wastewater Treatment Plant.

[1] The Service Area includes all sewered areas that drain to the KC WTD Hidden Lake Pump Station and all downstream neighborhoods that drain to the Boeing Creek Trunk and Richmond Beach Pump Station. Changes to the size and operations of the Hidden Lake Pump Station designed to fix its problems will also affect these downstream facilities.

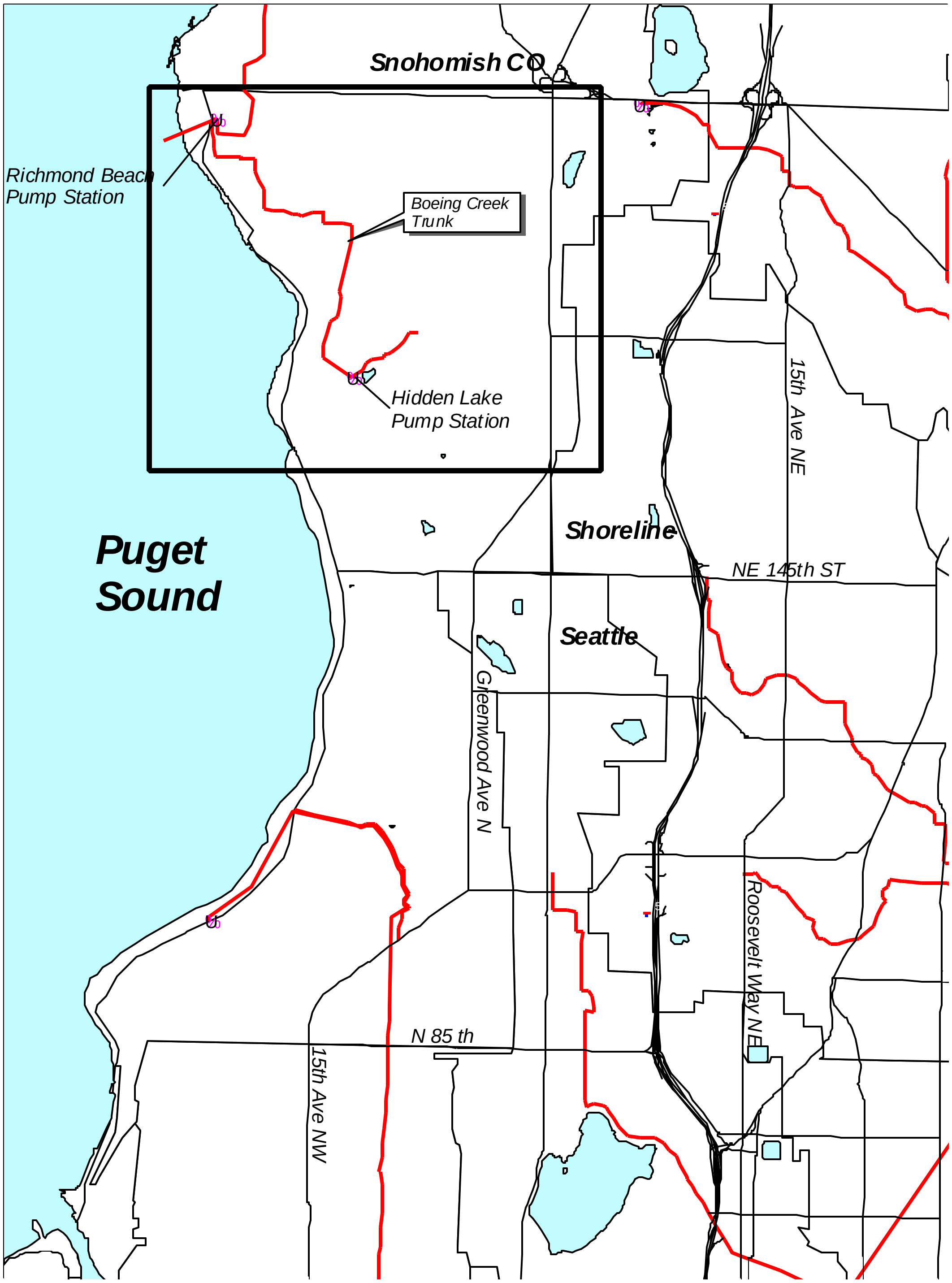

Figure 1: Hidden Lake Service Area
Location and Vicinity Map

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Legend

Road
Pump Stations
King County Conveyance Lines
Waterbodies

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King County
Department of Natural Resources

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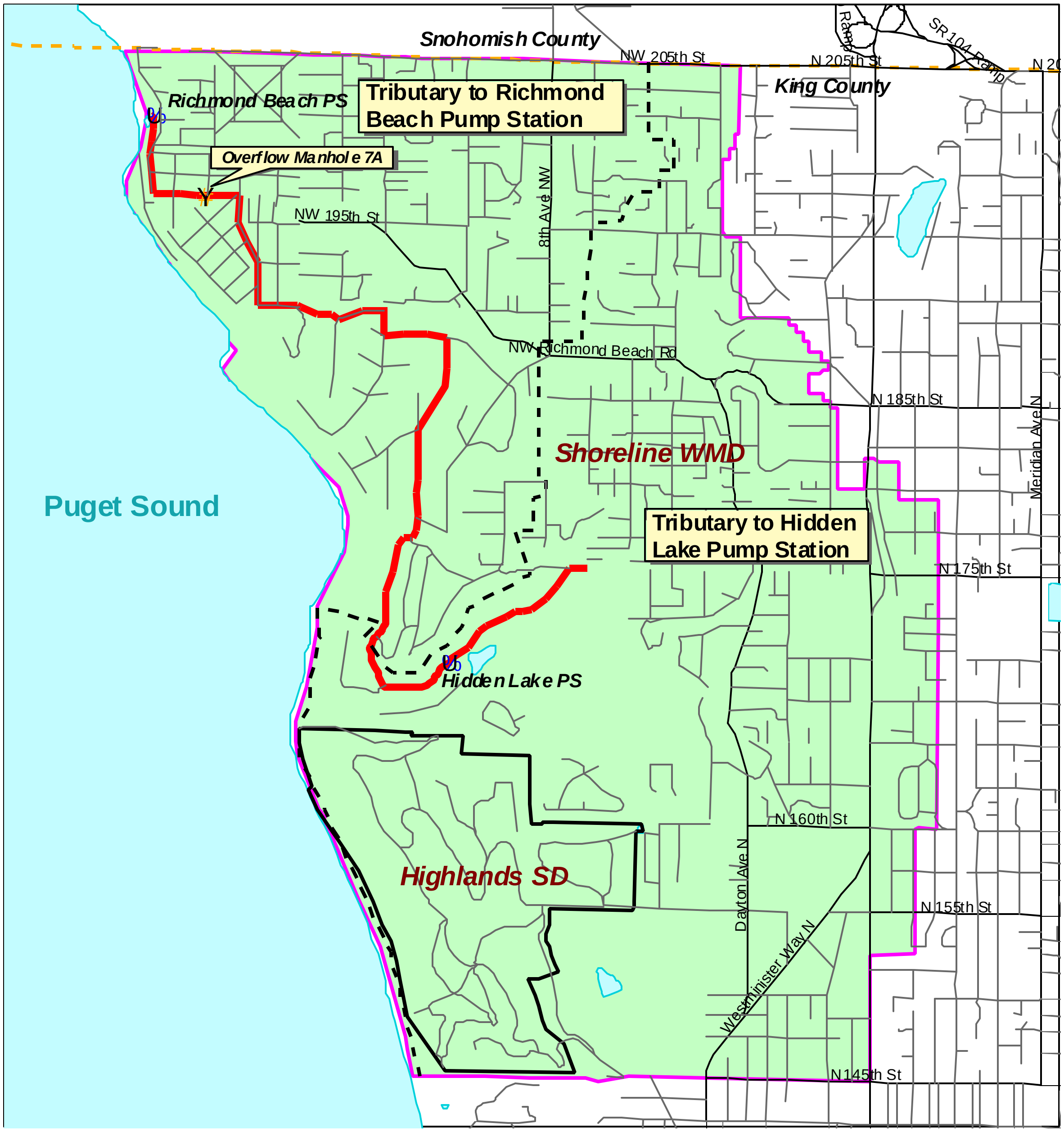

Figure 2: Hidden Lake Service Area

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May 11, 2000

Legend

- County Boundary
- KC Pump Stations
- Boeing Creek Trunk
- Hidden LK Service Area

At the time of the Seattle's first comprehensive sewerage plan, the 1958 *Metropolitan Seattle Sewerage and Drainage Survey* (the *1958 Plan*), three sewer systems were serving or about to serve parts of what is today the Hidden Lake Service Area. The Ronald Sewer District had been formed (in 1951) and financed and was planning its system to serve about 1.5 square miles. A second system had been built to serve the proposed Boeing Shopping Center (Aurora Avenue and 160th Street) but was not yet operating. A third system, the Highlands sewer system, collected sewage from a residential neighborhood of 0.7 square miles and discharged that sewage directly into Puget Sound without treatment.

Over the past 40 years, the boundaries and sewerage services provided in the Hidden Lake Service Area have expanded. Today, the entire Service Area is sewered, and a number local agency and King County owned pump stations help transfer wastewater through the system to the Richmond Beach Pump Station and the Edmonds Wastewater Treatment Plant.

Depending on the siting of the North Treatment Plant as proposed by the *Regional Wastewater Services Plan* (*RWSP*) and potential changes to King County's flow exchange program with the City of Edmonds, there may be changes to wastewater conveyance in the Service Area.

TASK 220: WASTEWATER CONVEYANCE FACILITY REVIEW

The Hidden Lake Service Area conveyance system can be summarized as follows:

- Shoreline WMD and Highlands SD collect and transport sanitary sewage to the King County WTD facilities using a network of gravity sewers, lift stations and force mains.
- King County WTD transports sewage along the Boeing Creek Trunk to the Richmond Beach Pump Station. The Hidden Lake Pump Station, located along the Boeing Creek Trunk, assists with flow transfer to Richmond Beach.
- Downstream of the Richmond Beach Pump Station, wastewater flows to the Edmonds Wastewater Treatment Plant, in accordance with King County's wastewater treatment sharing agreement with the City of Edmonds.

Several capacity issues have been identified at the Hidden Lake Pump Station and in the downstream conveyance system. Generally, the capacity of the pump station and downstream facilities is insufficient for wet weather conditions. There are also documented mechanical problems with the Hidden Lake Pump Station. Sanitary sewer overflows at the pump station occur more than once per year due to capacity limitations and/or mechanical failures. Specific areas of concern in the Service Area include:

1. The limited capacity of the Boeing Creek Trunk and the Hidden Lake Pump Station as well as documented mechanical, instrumentation and control, and electrical problems have created backups upstream of the pump station.

2. Two Shoreline pump stations (nos. 4 and 5) transfer wastewater to the Hidden Lake Pump Station. When both Shoreline pump stations are in operation, the flow volumes are sufficient to stress the Hidden Lake Pump Station capacity, regardless of the quantity of influent from the Boeing Creek Trunk.

3. Sulfide-related corrosion and odor have been an on-going problem at the Hidden Lake Pump Station and in the downstream piping.

4. Sliplining sections of the Boeing Creek Trunk has reduced the hydraulic capacity of the system, resulting in an increase in the frequency and severity of storm impacts, including document overflows and backups into the local collection system.

TASK 230: CHARACTERIZATION OF EXISTING CONDITIONS

The design and construction of conveyance facility improvements for the Hidden Lake Service Area must consider the local natural environment. Environment related constraints may make one improvement alternative more costly or less feasible than another. Furthermore, the design of improvements must consider the future development and the related increase in local system wastewater flows. Task 230 examined constraints resulting from the existing environment and the changes in land use anticipated within the Service Area.

Natural Environment

The potentially most significant natural environmental constraints to any conveyance improvement projects within the Service Area would be construction along the Boeing Creek corridor[2], along the Puget Sound shoreline, and the along the bluffs near Richmond Beach/Innis Arden. The Boeing Creek corridor has steep, unstable slopes, seeps, and forested, mature vegetation. Any of these conditions may place significant constraints on construction activities. Construction along Puget Sound could also involve significant permitting and mitigation for shoreline and estuarine wetland disturbance as well. Construction through the bluffs represents challenges related to unstable slopes and potentially significant erosion hazards. These challenges will need to be addressed during the study and design of any projects in the area. Alterations to areas with large stands of trees should also be avoided as much as possible.

[2] The *Boeing Creek corridor* refers to the area along the Boeing Creek surface stream, which should not be confused with the *existing trunk corridor*, or *Boeing Creek Trunk corridor* which refers to the alignment of the Boeing Creek Trunk sewer.

Changes in Land Use

The Service Area is primarily comprised of single family residential units. The Service Area is approximately 100 percent sewered and is presently experiencing less than one percent annual growth. Without changes to the present zoning, there is little room for further growth in most of the Service Area. There is some potential some multi-family development along Aurora Avenue, Richmond Beach Drive, and possibly at Point Wells. According to Shoreline WMD, the local agency sewers have enough excess capacity to handle modest growth. Any growth within the Service Area will increase base sanitary flows to KC WTD facilities such as the Hidden Lake Pump Station and Boeing Creek Trunk (which is important for defining low flow and the range of facility operation).

TASK 240: ALTERNATIVES TO SOLVE HIDDEN LAKE CAPACITY PROBLEMS

Task 240 required the CSI team to develop and evaluate preliminary alternatives for solving the capacity problems within the Service Area, and the mechanical problems at the Hidden Lake Pump Station. The task began by developing flow projections based on population forecasts, and infiltration and inflow (I/I) estimates for the Hidden Lake Service Area for future years. Then, using those flow projections, alternative strategies for reducing overflows to the KC standard of once per 20 years were developed and needed facilities sized. A planning level cost for each alternative was computed, and the costs were compared.

Service Area Flow Projections

KC WTD used observed flows at the Richmond Beach Pump Station along with a more extensive set of flow data from the Lake Ballinger Pump Station to calibration its I/I model[3]. The calibrated model was used to generate projections of the 20-year peak I/I flow. Base flows estimated from population forecasts along with the effects of sewer deterioration[4] were included to estimate the 20-year peak flow in 2050. The 20-year peak flow along the Boeing Creek Trunk was estimated from the locations of major connections from the local system and the contributing sewered area to each of the pipeline sections (Table 1)

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[3] The frequency of overflows upstream of the Richmond Beach Pump Station prevented the gauge at Richmond Beach from recording the full range of flow conditions, making the use of Lake Ballinger Pump Station flow data necessary. After observing the similar rainfall-derived I/I response at the Richmond Beach and Lake Ballinger flow monitors for storms small enough to not produce an overflow, KC WTD was able to assume a hydrologic similarity between the two basins to calibrate its I/I model and generate flow projections.

[4] Sewer deterioration was assumed to result in a 7 percent per decade increase in I/I until 2030.

Table 1. Boeing Creek Trunk existing conveyance capacities and capacity requirements at 20-Year peak flow

Reach	Capacity (mgd)	Base Flow (mgd)	20-Year Peak Flow (mgd)	Additional Capacity Required (mgd) [a]
B00-49 to HLPS	5.9	1.0	8.4	2.5
HLPS to B00-38	3.8[b]	1.3	11.8	8.0
B00-38 to B00-29	7.4	1.5	12.9	5.5
B00-29 to B00-23	5.5	1.5	13.5	8.0
B00-23 to B00-17	6.1	1.9	16.8	10.7
B00-17 to B00-04	9.6	2.0	17.7	8.1
B00-04 to RBPS	7.8	2.1	18.5	10.7

a Based on KC WTD population forecasts for 2050.

b Pump station capacity.

The improvements required to address the problem of insufficient flow capacity must increase the conveyance capacity and/or reduce the flows through these facilities

Development of Conveyance System Improvement Alternatives

As provided for in the scope of work for the project, the CSI project team developed three alternatives for reducing the frequency of conveyance system overflows to once per 20 years. These alternatives are as follows:

A. Upgrading the capacity of conveyance facilities and maintaining current wastewater routing.

B. Using storage to control conveyance system overflows.

C. Diverting peak wet weather flows away from the Boeing Creek Trunk.

Each alternative addresses the replacement, upgrading, and/or construction of new King County facilities, construction factors, planning and permitting issues, planning level costs, and impacts on other King County facilities. Year 2050 flow projections were used in designing these alternatives, where the Service Area is assumed fully developed. Using a 2010 planning horizon would reduce the size of required facilities but would not eliminate the need for additional facilities. The relative costs of the three alternatives to control the 20-year peak flow would not be significantly affected by shortening the planning horizon.

Following completion of the development of the three alternatives, additional alternatives, most of which involve variations on Alternatives A, B, and C, were offered by King County staff. The alternatives considered for the Hidden Lake project are summarized in the following paragraphs.

Alternative A: Upgrading the Capacity of Conveyance Facilities and Maintaining Current Wastewater Routing

The capacity of the conveyance system could be increased by replacing the 37 year old Hidden Lake Pump Station with a pump station approximately three times as large as the existing station, adding capacity to the Boeing Creek Trunk with a new force main and parallel gravity sewer, and retrofitting/upsizing the Richmond Beach Pump Station (see Task 240, Figure 4).

Alternative B: Using Storage to Control Conveyance System Overflows

Alternative B uses storage of peak storm flows as a method of controlling system overflows while limiting the need for upgrading King County facilities. An off-line storage tank could be associated with either the Hidden Lake or Richmond Beach Pump Station. The tank would need to have a capacity of 2.4 MG if the facility were constructed in association with the Hidden Lake Pump Station. A 1.5 MG tank would be needed if it were constructed at the Richmond Beach Pump Station. Additional facility upgrades would be required with either alternative (see Task 240, Figure 5).

Alternative C: Diverting Peak Wet Weather Flows Away from the Boeing Creek Trunk

Alternative C would avoid upgrading some existing facilities by routing peak storm flows away from the Hidden Lake Pump Station and Boeing Creek Trunk. The collection point for the conveyance bypass line would be located at the upstream end of the Boeing Creek Trunk (manhole B00-49). A pump station would be required to move the flows out of the basin. There are two options for sizing the pump station, 8.4 mgd or 11.8 mgd. (These sizes were increased to 9.7 mgd and 13.2 mgd, respectively, using the Task 250 updated flow projections.) Option C1 involves construction of an 8.4 mgd pump station (9.7 mgd in TM250) to intercept the 20 year peak flow at manhole B00-49, above the Hidden Lake Pump Station. In this case, the Hidden Lake Pump Station could remain at its current size, but downstream reaches of the Boeing Creek Trunk would require additional capacity. Alternatively, an 11.8 mgd diversion pump station (13.2 mgd in TM250) could be constructed near manhole B00-49. The Hidden Lake Pump Station effluent would be redirected towards the Boeing Creek Trunk in dry weather or small storms. During large storms, Hidden Lake Pump Station effluent would be pumped to the new diversion pump station and from there towards the Richmond Beach Pump Station. Thus, even during large storms, the Boeing Creek Trunk would not require additional capacity (see Task 240, Figure 6).

Alternative D1: Route Flows to the Lake Ballinger Pump Station

Wastewater could be routed into the McAleer and Lyon basin by a new pump station and a 3-mile long force main/gravity sewer. The new sewer would discharge to the Lake Ballinger Pump Station. With a capacity increase, the Lake Ballinger Pump Station could pump the wastewater to either the Edmonds Wastewater Treatment Plant or the McAleer Trunk, and to the West Point Treatment Plant. The bi-directional pumping capability of the Lake Ballinger Pump Station would provide flexibility to deliver wet weather flows to a new North

Treatment Plant, once a site is determined. Pumping first to the Lake Ballinger Pump Station is an indirect route and requires two pump stations, each with more than 150 feet of static lift. Pumping to the McAleer Trunk would add flow to the Kenmore Interceptor and downstream sections of the King County conveyance system that are already overloaded in wet weather conditions; West Point Treatment Plant would also be affected (see Task 240, Figure 7).

Alternative D2: Route Flows to the Matthews Park Basin

A three and a half mile long force main/gravity sewer could be routed to the southeast to the beginning of the North Lake City Trunk and into the Matthews Beach basin. This would help reduce the number of storm impacts in the Service Area and would add no additional flow to the Edmonds Treatment Plant. Other parts of the King County conveyance system would be stressed. The North Lake City Trunk would require additional capacity to accept the diverted flows. The North Lake City Trunk discharges to the Thornton Creek Interceptor and the Matthews Park Pump Station. Similar to Alternative D1, capacity constraints in the conveyance system and at the West Point Treatment Plant impact this alternative (see Task 240, Figure 7).

Alternative D3: Route Flows Along Beach/Railroad Tracks

A new pressure sewer could be constructed to run towards Shoreline WMD Pump Station 4, then down the bluff near Puget Sound. The pipeline could run northward either along the railroad tracks or the beach to the Edmonds Wastewater Treatment Plant. The wet weather flows could be conveyed to the Richmond Beach Pump Station entirely by gravity, avoiding most major upgrades to Hidden Lake Pump Station and Boeing Creek Trunk. Despite these potential capital cost and operations and maintenance advantages, a number of concerns that make this alternative less attractive. Concerns include King County’s past experience with an overflow line down the bluff that was disrupted by land movements. The railroad tracks at the bottom of the bluff run so close to the hillside that pipe construction would have to occur on the west side of the tracks, which borders a wetland with potential salmon habitat. Finally, the deposition of solids along this flat pipeline could result in odors on the beach during summertime, if mitigation measures were not specified during project design (see Task 240, Figure 7).

Alternative D4: Route Flows Through a Deep Tunnel Along NW 175th Street

A pressure sewer could be tunneled underneath NW 175th Street from 6th Avenue NW to 15th Avenue NW, meeting up with the Boeing Creek Trunk near manhole B00-33. This option has the advantage of being more direct than the current Boeing Creek Trunk route, and it would eliminate the need to upsize the Hidden Lake Pump Station. Flows would not be reduced along most of the Boeing Creek Trunk; the tunnel would need to be continued to manhole B00-14. NW 175th Street is a winding residential street, so the tunnel would have several turns. The maximum depth would be approximately 100 feet, requiring deep jacking/receiving pits (see Task 240, Figure 7).

Alternative D5. Using Primary Clarifiers for Storage at the Richmond Beach Pump Station

The Richmond Beach Pump Station was originally a treatment plant, and the project team examined the feasibility of using the primary clarifiers there for storage. As noted in Alternative B2, total storage volume of 1.5 MG would be required at this location, and if a large enough portion of the storage were provided by the clarifiers, there could be a significant cost savings. According to County WTD personnel, the clarifiers were not dismantled during the Richmond Beach Flow Transfer Project, although the top few feet of the vertical walls were probably damaged. However, the clarifiers could provide a maximum storage volume of only 0.2MG, far less than the 1.5 MG of storage required by Alternative B2.

Alternative D6. Redirecting Part of Shoreline WMD Basin 14, Reducing Size of New Pump Station

Alternative C proposed to build a new pump station and force main to convey the wastewater generated in Shoreline WMD Basin 14 to the north and out of the Hidden Lake Service Area. Alternative D6 is similar to Alternative C, the key difference being that Alternative D6 would redirect a portion of the local collection system to connect with the new force main at its gravity transition point. This would reduce the required pumping capacity of the new pump station and size of the force main, resulting in a potential cost savings on these facilities. An examination of a contour map shows that the local topography varies along the proposed diversion route, so that a gravity sewer would need to be constructed relatively deep (see Task 250, Figure 4).

Alternative D7. Tunnel Storage and Conveyance

Alternative D7 proposed to construct a 10- to 14-foot diameter tunnel from either manhole B00-49 or the Hidden Lake Pump Station to the Boeing Creek Trunk in the vicinity of the inverted siphon forebay (B00-29). The tunnel would allow enough storage to control the 20-year design storm at the Hidden Lake Pump Station. The outlet of the tunnel would be regulated in order to limit overflows downstream of its connection with the Boeing Creek Trunk. Constructing a tunnel solely in the public right-of-way would have to consider the many turns of the local streets. A number of access shafts could be dug to allow the tunneling machine to be lifted out of the deep tunnel (greater than 100 feet in places) and reoriented. The density of local housing must be considered for this alternative, because the tunnel would probably have to be constructed partly under private property. The County would need to acquire easements from property owners prior to tunnel construction (see Task 250, Figure 5).

Alternative D8. Interim Solutions to Reduce Overflow Frequency Until the North Treatment Plant has been Sited

As part of a program to manage the 20-year peak flow, this alternative uses a combination of interim remedies to reduce the number of system overflows in the Service Area. The level of sanitary sewer overflow (SSO) control could initially target the once-in-two year or once in five year peak flow. After a site for the North Treatment Plant is chosen, a program of facilities improvements and/or I/I reduction would be implemented to meet the KC standard of one overflow per 20 years. By initially seeking an interim solution that is a part of a phased program of flow management, this alternative would attempt to avoid constructing costly facilities that may be underutilized after the North Treatment Plant is in operation. The planning horizon for this alternative is 2010, rather than 2050 as was used in other alternatives. This date coincides with the scheduled startup date for the North Treatment Plant. An interim solution might include some combination of I/I reduction, inline storage, additional conveyance capacity, and treatment of SSO discharges.

<u>Alternative D9. Phasing Portions of Alternative C Construction on an As-Needed Basis</u>

The regional I/I program will be implemented between winter 2000 and 2004 and will consist of regional flow monitoring and pilot projects to assess I/I impacts on the King County conveyance system. The flow monitoring will refine our understanding of I/I rates in the Service Area; the selected pilot projects will refine our understanding of the cost-effectiveness of I/I removal. The flow data collected during the regional I/I study will help provide greater confidence in the Service Area conveyance system design flows. The location of the North Treatment Plant will affect the sizing and the need for some of the conveyance facilities proposed in various alternatives. By phasing the project, the County would have greater control over the final project costs, and will have the local agency (Shoreline Water Management District) as an integral partner in managing all wastewater flows in the Service Area.

Cost Estimates for Primary Alternatives

Planning level cost estimates were prepared for Alternatives A, B, and C based on cost curves and information gathered from other projects (Table 2). The Boeing Creek Trunk improvements cost estimate takes into account material costs, excavation pits and tunneling, traffic control, and surface restoration as required. The Hidden Lake Pump Station cost estimate includes odor control and chemical dosing. The cost estimate for the Richmond Beach Pump Station expansion is based on the 1991 project cost for pump station construction ($6.25 million). The expansion would increase the pump station capacity by 80 percent; the original cost has been multiplied by 80 percent and a 4 percent annual inflation rate has been applied. The cost of the Richmond Beach–Edmonds Interceptor and force main includes material costs, excavation and trench support, traffic control and surface restoration. A $5.5 per gallon project cost was assumed for the storage tank cost, based on estimating techniques used for King County *RWSP* and combined sewer overflow projects. This cost assumes that a suitable location for the storage tank is available. The odor control and chemical dosing equipment costs are based on previous consultant experience. Land acquisition costs for new pipeline routes (Alternative C) are also included. Costing assumptions include 10 percent for contractor’s operations and profit, 10 percent mobilization/demobilization, 30 percent contingency, 8.6 percent sales tax, and 35 percent for design. These cost estimates also include 50 percent for King County allied costs; these allied costs were not included in the Task 240 report, but are included here to be consist with the Working Alternative cost estimates (see Table 8).

Table 2. Summary of project cost estimates for Alternatives A, B, and C[a]

Conveyance System Improvement Alternative	Cost (million dollars)
Alternative A – Increase conveyance capacity	43.4
Alternative B1 – Offline storage at the Hidden Lake Pump Station	47.0
Alternative B2 – Offline storage at the Richmond Beach Pump Station	41.0
Alternative C1 – Diverting Peak Flows Away from Boeing Creek Trunk with 8.4 mgd Pump Station	43.8
Alternative C2 – Diverting Peak Flows Away from Boeing Creek Trunk with 11.8 mgd Pump Station	38.1[b]

a. These project cost estimates include 10% for contractor's O&P, 10% for mobilization/demobilization, 30% contingency, 8.6% sales tax, 35% for design and 50% KC allied costs. The estimates in this table differ from those in Task 240, Table 17, because the 50% for KC allied costs were not included in Task 240.

b. As the preliminary working alternative, refined cost estimates were developed for Alternative C2. The refinements resulted in a lower estimated cost than in Task 240 (once KC allied costs are added to the Task 240 estimate).

The various Alternatives developed for controlling SSOs in the Hidden Lake Service Area are summarized in Table 3.

At the conclusion of Task 240, the CSI project team selected Alternative C2 (diversion pump station and sewer) and Alternative D3 (waterfront sewer) as working alternatives, and directed that those two alternatives be carried into Task 250 for a preliminary environmental evaluation.

Table 3. Summary of Hidden Lake alternative analysis

Alt. No.	Description	Team Action	Reason
A	Capacity upgrades using existing alignment	Modified	Complete upgrade rejected because of construction difficulties due to buried utilities in right-of-way, but some segments might be upgraded without utility complications
B1	2.4 MG storage at Hidden Lake Pump Station	Rejected	Tank siting problems, higher cost, higher O&M requirements
B2	1.5 MG storage at Richmond Beach Pump Station	Rejected	Does not avoid construction difficulties noted for Alt. A; probability of piling to support tank drives up cost
C1	Diverting flow from Hidden Lake PS w/9.7 mgd pump station (updated size from Task 250)	Rejected	Higher cost than C2 because it requires a new pump station plus upsizing Boeing Creek facilities
C2	Diverting flow from Hidden Lake PS with 13.2 mgd pump station (updated size from Task 250)	Working Alternative	Lowest cost alternative because a larger pump station eliminates need to upgrade Boeing Creek facilities
D1	Pump flow to Lake Ballinger PS	Rejected	Transfers wet weather flows to other maximized/optimized King County conveyance facilities
D2	Pump to North Lake City Trunk and Matthews Park basin	Rejected	Transfers wet weather flows to other maximized/optimized King County conveyance facilities
D3	New sewer over bluff and along shoreline to Edmonds WWTP	Environ. Evaluation	Gravity option a plus, but environmental concerns (ESA, sensitive areas) limit viability
D4	Tunnel new pressure sewer under NW 175th St.	Rejected	Tunnel would be long, deep and have many turns, driving up costs
D5	Use old primary clarifiers at Richmond Beach for storage	Rejected	Storage capacity in clarifiers Insufficient to significantly lower costs relative to Alts. A & B2
D6	Direct part of Basin 14 flows out of Service Area	Rejected	Reduces size of Hidden Lake pump station, but requires long, deep directional drilling
D7	Tunnel storage and conveyance	Rejected	Would require difficult tunnel easements under private property; limiting tunnel to public r-o-w not feasible because of number of street turns
D8	Short term solutions to reduce overflows until North Treatment Plant built	Working Alternative	Controlling 2 year storm requires significant investment now with greater investment required later, but underutilized facilities are avoided and flexibility is maintained
D9	Phase construction on as-needed basis, waiting to see how regional I/I program, North Treatment Plant impact basin	Working Alternative	Can be used with working alternative C or any other alternative to eliminate costs that might not be needed if these programs reduce Hidden Lake problems

TASK 250: ALTERNATIVE EVALUATION, REFINEMENT, AND SELECTION OF A WORKING ALTERNATIVE

Whereas Task 240 involved development of a range of alternatives to solve Service Area conveyance capacity and Hidden Lake Pump Station mechanical problems, Task 250 required refinement of promising alternatives to the point where a working alternative could be selected. Updated flow projections were considered, and the impact of the regional I/I reduction program were discussed. Limitations and impacts of the natural environment were considered. Then a working alternative was synthesized from the various promising alternatives and approaches.

Updated Flow Projections for the Service Area

The capacity analysis described above was based on preliminary flow projections provided by King County. When the Task 240 report was prepared, there was a lack of available local flow data for the local Service Area basins. Since preparation of the Task 240 report, the County obtained and analyzed additional flow monitoring data collected by the Shoreline WMD within Basin 14, upstream of the Hidden Lake Pump Station (Figure 3). The new flow data show that Basin 14 has higher peak infiltration and inflow (I/I) flows that previously assumed. The data do not give any indication whether previous I/I estimates for basins downstream of the Hidden Lake Pump Station were accurate or complete.

The monitored sections of Basin 14 have higher peak I/I rates than the Service Area average of 4,710 gpad for the 20-year. Because not all sections of Basin 14 were isolated by flow monitoring, some basins were assigned I/I rates based on I/I rates in neighboring sub-basins with similar land use patterns. Table 4 gives a new estimate of the 20-year peak flow at the Hidden Lake Pump Station by summing up the peak flows from the individual sub-basins.

Table 4. Comparing peak flows at the Hidden Lake Pump Station

Source	5-Year Peak Flow (mgd)		20-Year Peak Flow (mgd)	
	Year 2000	Year 2050	Year 2000	Year 2050
Task 240 Flows [a]	8.2	9.7	9.9	11.8
Updated Flows	8.2 [b]	9.7 [c]	11.1 [b]	13.2 [c]

a. Data from Task 240 report, Table 1.

b. Flows are summed from Task 250 report, Table 1.

c. Task 250 flow projections for 2050 assume base flow and I/I increase at the rate established in Task 240 (seven percent per decade through 2030).

Basin 1 and 2, located near the Richmond Beach Pump Station, are probably also high I/I areas. The sewers in these basins are among the oldest in the Service Area and published Shoreline WMD data show a strong hydrograph response to rainfall. The time-series flow data were not available for this study, so the 20-year peak flow for these basins has not been estimated.

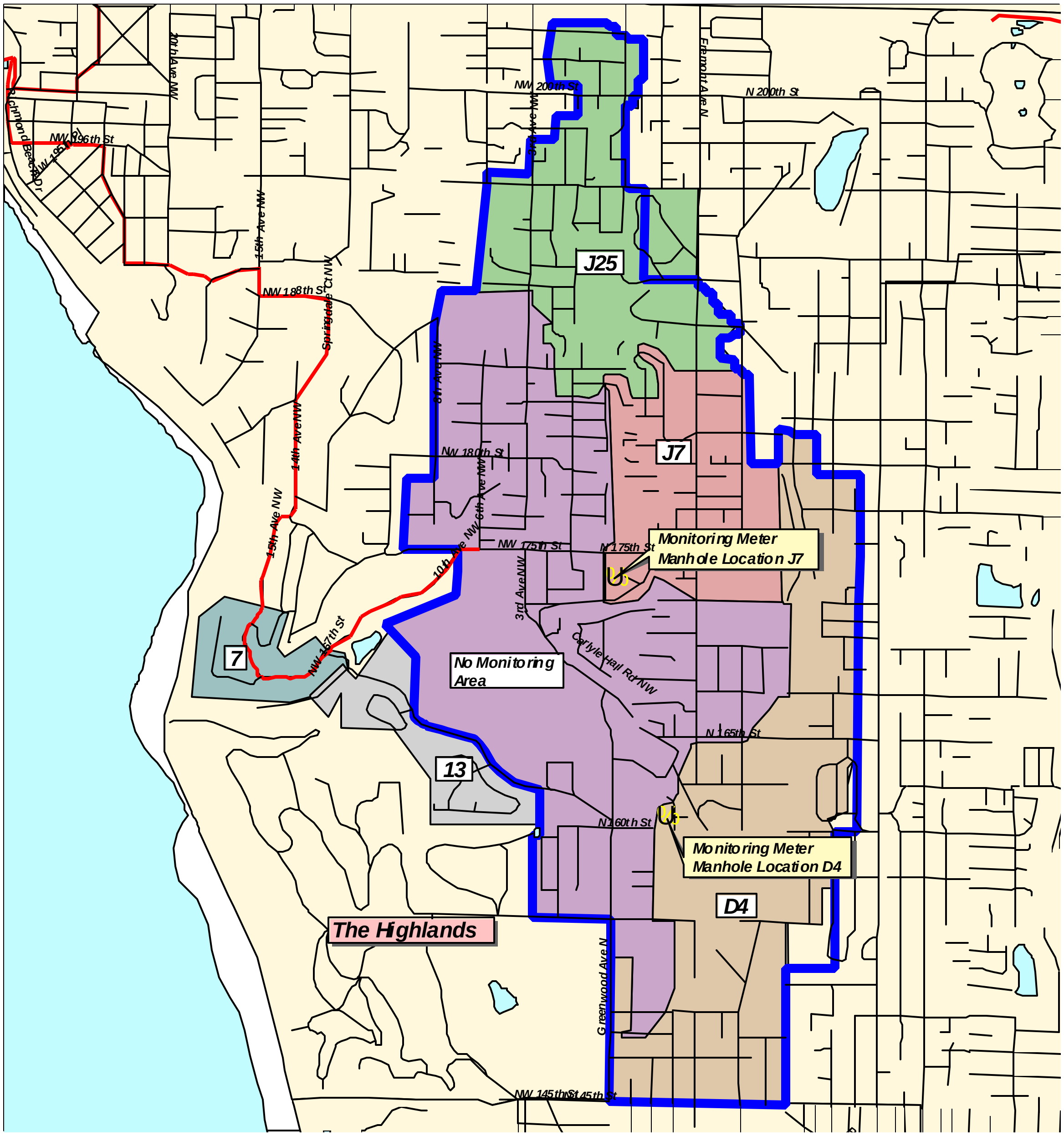

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Figure 3

Hidden Lake PS Portable Monitors

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April 17, 2000

Legend

- Roads
- KC Conveyance Line
- Shoreline WMD Basin 14 Boundary
- Service Basins

Refined Population Projections and Base Flow Projections

The population forecasts used to develop base flows for the Task 240 report were refined in Task 250 by using GIS analysis techniques to sum the population forecasts for the individual Traffic Analysis Zones (TAZ) that are contained in the Service Area[5]. The TAZ population data were provided by the Puget Sound Regional Council (PSRC)[6]. The data source is the same as Task 240, but the analysis here is more detailed. These refined forecasts show that continued slow growth is expected throughout the 50-year planning window (Figure 4, Table 5).

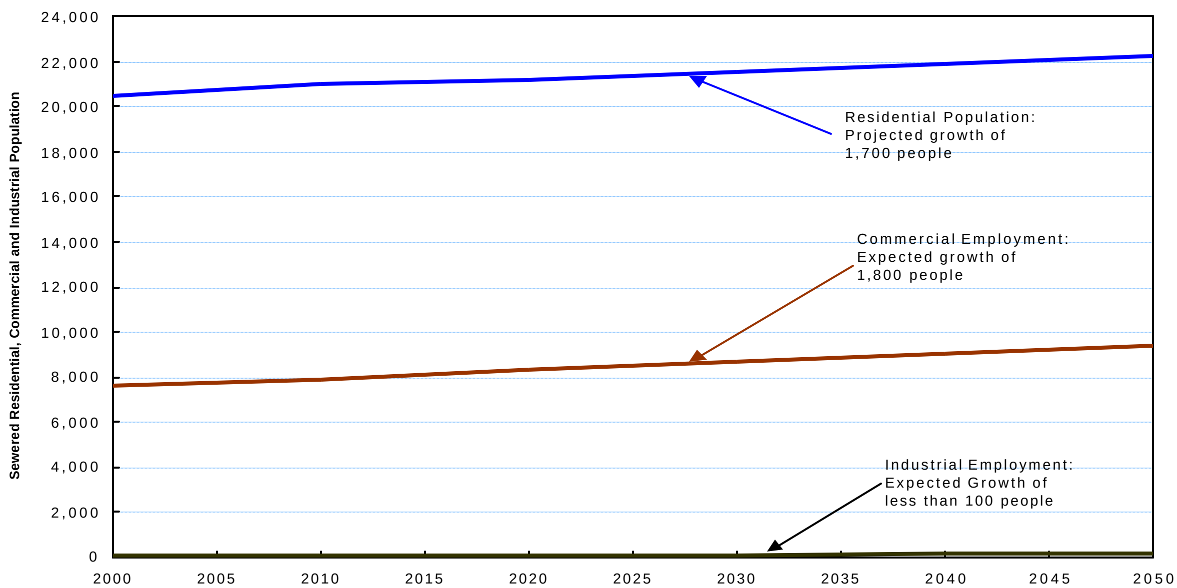

Figure 4. Refined residential population, commercial and industrial employment forecasts for the Service Area.

For comparison with KC WTD forecasts, revised population forecasts for the Service Area were derived from the *1999 Shoreline Comprehensive Plan* (*Shoreline Pla*n) [7] and the draft

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[5] For TAZs that span the Service Area boundary, population is calculated (proportionately) according to the fraction of the TAZ within the Service Area

[6] Task 240 used wastewater basin-level forecasts while Task 250 used the more detailed TAZ-level population forecasts.

[7] The planning area considered in the *Shoreline Plan* includes all of the City of Shoreline, plus some potential annexation areas. The City of Shoreline used PSRC's 1998 set of forecasts for its population and employment forecasting. Appendix A of the *Shoreline Plan EIS* presents population forecasts by neighborhood in for a 20-year window beginning in 1996. The stated boundaries were used to determine which of the neighborhoods are located within the Service Area. The population forecasts are expressed in terms of dwelling units (DU), which were converted to population by assuming 2.4 residents per DU.

Shoreline WMD Comprehensive Sewer Plan. The *Shoreline Plan's* forecasted residential baseline population and growth rate is similar to the KC WTD forecasts (Table 5).

Table 5. Refined population forecasts for Service Area[a]

Year	Residential	Commercial[c]	Industrial[c]
Task 250: Refined KC WTD Forecasts (based on PSRC TAZ data, June 1999)			
2000	20,483	7,572	66
2010	21,019	7,840	70
2016	21,098[b]	8129[b]	81[b]
2020	21,151	8,322	88
2030	21,549	8,664	99
2040	21,885	9,038	110
2050	22,218	9,413	120

Year	Residential	Commercial	Industrial
Task 250: 1999 Shoreline Plan Forecasts			
1996	18,418	N/A	N/A
2000	18,899[b]	N/A	N/A
2016	20,822	N/A	N/A

Year	Residential	Commercial	Industrial
Task 250: Draft Shoreline WMD Comprehensive Sewer Plan Forecasts[d]			
2000	19,919	N/A	N/A
2016	21,569	N/A	N/A
2020	21,981	N/A	N/A

a. These forecasts are for the entire Service Area: neighborhoods that drain to the Hidden Lake Pump Station and downstream neighborhoods served by the Richmond Beach Pump Station.

b. The reported residential population is linearly interpolated from previous and following time periods in order to provide easy comparison to the other forecasted data set.

c. KC WTD's commercial and industrial population is based on the PSRC's forecasting by U.S. Dept. of Labor Standard Industrial Classification (SIC) codes using Washington State Employment Security Department records.

d. The draft Shoreline WMD Comprehensive Sewer Plan dated May, 3, 2000, reported forecasted residential populations of 36,151 and 39,941 for 2000 and 2020 for the Shoreline WMD coverage area. The baseline population is based on the number of Residential Customer Equivalents (RCE) recorded by the District, and the growth rate is based on PSRC's 1995 TAZ study. The populations shown above have been computed using the fraction of the Service Area within Shoreline WMD coverage area (assumes uniform spatial population distribution), plus 245 residents for the Highlands (102 DU and 2.4 people per DU).

The KC WTD population forecasts were compared with *Shoreline Plan* and Shoreline WMD forecasts included for the area tributary to the Hidden Lake Pump Station. The Shoreline WMD forecasts ranged from 8 to 17 percent higher than the KC WTD forecasts between

2000 and 2020, with the largest difference occurring in 2020 (12,914 by Shoreline WMD; 11,024 by KC WTD). The difference may result because the GIS-based, TAZ analysis used to develop the KC WTD forecasts is less accurate for smaller areas, and because the Shoreline WMD faced difficulties applying population forecasts from available sources because the areas covered by these forecasts were not coincident the District boundaries.

Impacts of Infiltration and Inflow Reduction

The project team examined the potential impacts of infiltration and inflow reduction for the Service Area. Two I/I reduction scenarios were examined:

1. A 30 percent basin-wide reduction in the peak 20-year I/I as a benchmark based on the goals of the KC regional I/I program.

2. A higher level of targeted I/I reduction for its effectiveness in limiting the number of new facilities to be constructed.

Infiltration and inflow account for about 86 percent of 5-year peak flow and 89 percent of the 20-year peak flow in the Hidden Lake Service Area's wastewater conveyance system, based on the projections of King County's calibrated I/I model (see Table 6). During wet season storms, the capacity of the existing conveyance facilities are periodically exceeded, resulting in sanitary sewer overflows (SSOs). According to the County, there is currently an average of three SSO events each year at the Hidden Lake Pump Station wet well[8]. Downstream of the Hidden Lake Pump Station, there is a designed overflow at manhole 7A of the Boeing Creek Trunk, and there have been reports of overflows at other manholes along the trunk (see Task 210 report).

Table 6. I/I contribution to peak flows at the Richmond Beach Pump Station[a]

	Peak Flow (mgd)	I/I Flow (gpad)	I/I Flow (mgd)	% Attributable to I/I
5-Year Storm Event	15.2	4,530	13.0	86%
20-Year Storm Event	19.9	6,160	17.7	89%

a The flow projections were provided by KC WTD for the year 2050. Their estimates assume a seven percent per decade increase in I/I for the decades through 2030. The updated flow projections from the previous section are incorporated upstream of Hidden Lake. The flow projections downstream of Hidden Lake were not updated because no additional flow data were collected or analyzed for this part of the collection system.

8 This estimate includes hydraulic capacity related overflows and overflows resulting from mechanical failures. Hidden Lake Pump Station overflows are directed to Shoreline WMD Pump Station No. 4, where approximately 75 percent are controlled and pumped back to the Hidden Lake Pump Station. The other 25 percent of overflows discharge to Puget Sound.

Table 7 shows the projected 20-year peak flow at the Hidden Lake and Richmond Beach Pump Stations and along the Boeing Creek Trunk without I/I reduction and following a 30 percent reduction of I/I.

Table 7. Impact of I/I reduction on existing facilities

Reach	Length (ft)	Design Flow[a] (mgd)	20-Year Peak Flow (mgd)	20-Year Peak Flow After 30% I/I Red. (mgd)	Excess Flow (mgd)[c]
B00-49 to HLPS	2,803	5.9	11.9	8.4	2.5
HLPS to B00-38	2,375	3.8[b]	13.2	9.2	5.4
B00-38 to B00-29	2,476	7.4	14.3	10.0	2.6
B00-29 to B00-23	3,316	5.5	14.9	10.4	4.9
B00-23 to B00-17	2,260	6.1	18.2	12.7	6.6
B00-17 to B00-04	3,718	9.6	19.1	13.4	3.8
B00-04 to RBPS	872	7.8	19.9	13.9	6.1
RBPS	N/A	10.4	19.9	13.9	3.5

a. Design flow calculated with Manning's equation using friction factor, n = 0.013

b. Equal to the pumping capacity of the Hidden Lake Pump Station.

c. Excess flow after 30 percent I/I reduction.

As Table 7 shows, removing 30 percent of peak wet weather I/I would help reduce the frequency of overflows but would not control the 20-year storm. With a 30 percent reduction in peak I/I, new facilities would still be necessary. Targeted I/I reduction could be used with other control strategies to delay some construction. An accurate estimate of the costs of this level of rehabilitation cannot be developed without extensive flow monitoring, source detection, and the development of unit costs for I/I removal, such as will be provided by the KC regional I/I program.

Selection of a Working Alternative

The consultant team was instructed to prepare alternatives that involved phased construction and combinations of demand management, storage and increased conveyance. The additional phased/combination alternatives were presented to KC staff at a decision workshop held on March 16, 2000. The objective of the workshop was to specify a working alternative that would meet the immediate upgrade needs at the Hidden Lake Pump Station, reduce the number of sanitary overflows in the service area, and achieve the KC 20-year control level.

The workshop began with a description of the current level-of-service problems in the Service Area, a review of future flow projections, and a recap of the alternatives that had been previously developed. Following the review of previous work, additional alternatives emerged by combining the following elements:

- Increasing the conveyance capacity along the existing corridor

- Incorporating storage to attenuate peak flows
- Managing demand by reducing I/I and/or reducing the amount of sewer deterioration
- Constructing a pump station and diversion sewer to carry peak flows away from the Boeing Creek Trunk

Working Alternative Description

The working alternative would initially retrofit or replace the Hidden Lake Pump Station to achieve a peak pumping capacity of 5.5 mgd[9], and parallel or replace a total of 6,400 lineal feet of the most capacity limited sections of the Boeing Creek Trunk. Increasing the pumping capacity at Hidden Lake and removing the bottlenecks in the Boeing Creek Trunk would allow the full capacity of the 10.4 mgd Richmond Beach Pump Station to be used. This combination of upgrades would reduce the number of storm related overflows to approximately one every 2 years. Providing 0.5 MG of storage upstream of the Hidden Lake Pump Station would, according to the best available flow information, further reduce the number of storm related overflows to one every 4 to 5 years. After the North Plant siting and regional I/I programs are completed (assumed 2005), the level of control would be brought to the KC standard of one overflow every 20 years by I/I reduction, additional storage and/or construction of a diversion pump station and sewer directed away from the Boeing Creek Trunk. The final flow projections and treatment plant location would be used for sizing and alignment of the new facilities.

This alternative provides:

- Short-term improvements that will reduce the frequency of overflows and long-term improvements will incorporate better flow projections and routing information.
- Time for the regional I/I program to work. Rather than accepting all flows from the component agencies, the County can work with these agencies to promote I/I control and system maintenance to manage peak flows.
- Expanded capacity in the Boeing Creek Trunk that will allow the Richmond Beach Pump Station to be fully utilized.

The decision to retrofit the Hidden Lake Pump Station or replace it with an adjacent pump station (possibly where the driveway is currently located) will be made after performing a

[9] Increasing the capacity of the Hidden Lake Pump Station from 3.8 mgd to 5.5 mgd and upgrading the downstream conveyance brings the capacities of these facilities in line with the Richmond Beach Pump Station. Both upgrades are essential to reducing overflows until the 20-year control plan is implemented. Increasing the capacity of the trunk sewer will reduce overflows at manhole 7A. Rebuilding or retrofitting the Hidden Lake Pump Station with a 5.5 mgd capacity will reduce the frequency of overflows from the wet well, while limiting force main velocities to 8 ft/s. All facilities would have sufficient capacity for the unattenuated 2-year peak flow.

detailed analysis in project predesign. The predesign team must investigate if larger pumps that meet the new design head and flow conditions could fit within the existing layout, and if these pumps could pump slowly enough to pass dry weather flows with continuous operation (i.e. alleviate current cycling problem). New electrical, instrumentation and control equipment will be necessary whether retrofitting or replacing the station. The amount of work involved and the necessity of maintaining operation of the pump station during construction may require that the existing station to be replaced. The cost estimates prepared in this section assume the Hidden Lake Pump Station is replaced with a new pump station.

If a new station is built, the design team must work closely with KC operations and maintenance staff to avoid the major operating constraint of the current station. During low flow periods, the small size of the wet well and range of operation of the pumps cause the pumps to frequency cycle on and off. This problem could be minimized by incorporating storage in the influent portion of the Boeing Creek Trunk, and choosing pumps that can operate slowly enough to continuously pump dry weather low flows. The existing overflow/relief sewer orientation would also have to be changed. Currently, the wet well influent from Shoreline Pump Stations No. 4 and No. 5 also forms the wet well overflow (see Figure 5). Backflow into this line would have to be eliminated by either reorienting the piping or installing an appropriate valve. A new pump station overflow/relief sewer could be installed in the upstream piping. All local connections were previously removed from the Boeing Creek Trunk, so locating the relief structure upstream of the pump station will not affect service to local customers so long as the overflow piping is large enough to prevent backups beyond manhole B00-49.

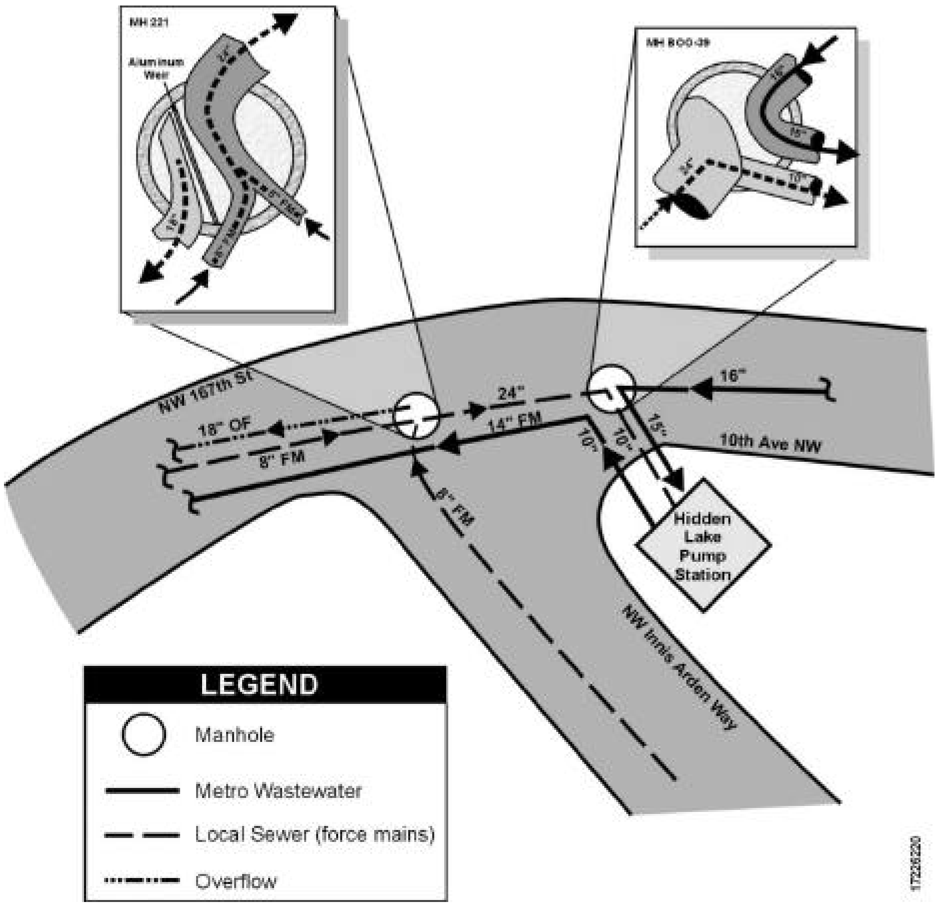

Figure 5. Influent, effluent and overflow piping in the vicinity of the Hidden Lake Pump Station

Figure 6 shows projected peak flows, current and pre-sliplining conveyance capacities along the Boeing Creek Trunk. The paralleling/replacement work is planned for the pipe segments between manholes B00-29 to B00-17 and B00-7 to the Richmond Beach Pump Station. These pipes are shown in the figure as not having enough capacity to pass the 2-year peak flow (see Figure 7 pipe locations).

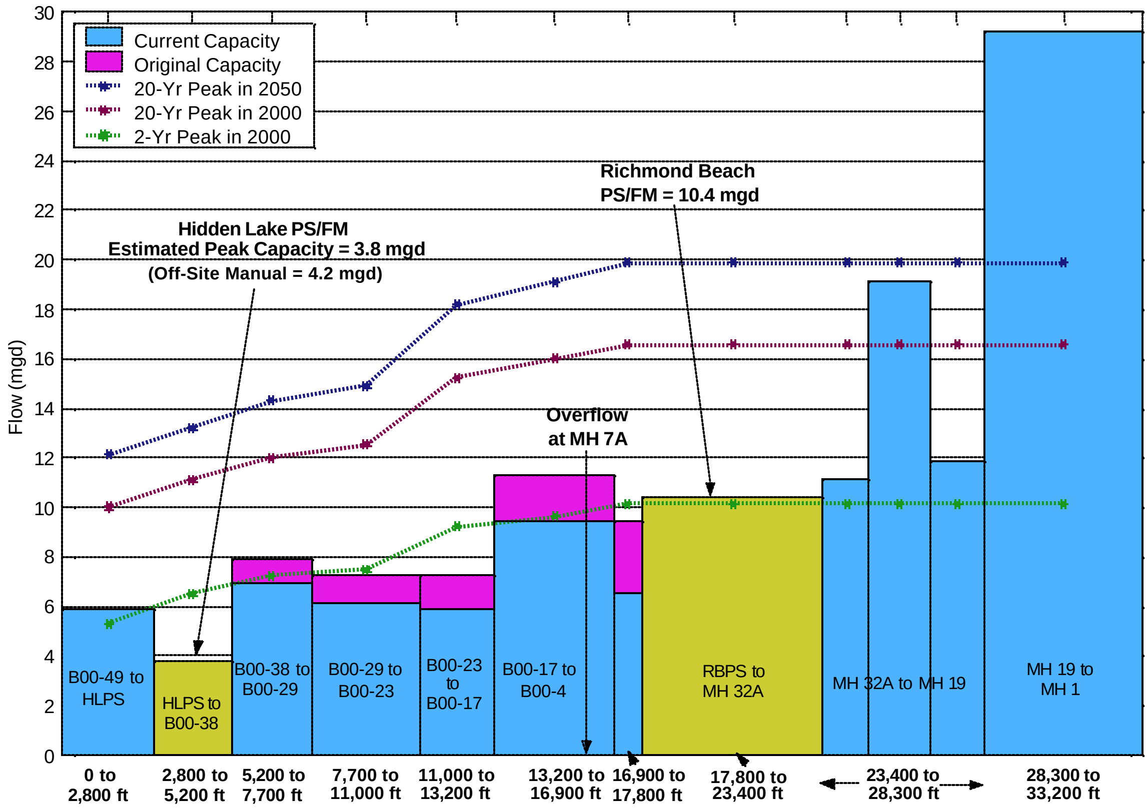

Figure 6. Peak flows and conveyance capacity in the Boeing Creek Trunk.

The CSI project team has performed a preliminary analysis of where the 0.5 MG of storage could be located. The relatively small, flat portion of the Hidden Lake Pump Station property would probably not be large enough to contain a 0.5 MG storage tank. If the new pump station is built adjacent to the existing pump station[10], the existing station's dry pit could be converted to storage after the new pump station is online, but this would only accomplish a small fraction of the 0.5 MG needed. One potential location for offline, gravity in/out storage is along NW 175th Street, between 6th and 10th Avenues NW. A storage tank and associated piping could be located on a section of the vacant property on the northwest corner of NW 175th Street and 6th Avenue NW. Alternatively, an 8-foot diameter offline pipe could be installed from B00-49 to B00-42 (Figure 7). This pipe would measure 1,450 feet in length and would contain approximately 0.5 MG of storage volume. These examples are included to illustrate that storage upstream of Hidden Lake is possible. The location and alignment of storage elements must be examined in greater detail during project predesign.

[10] Building the new pump station adjacent to the existing pump station would allow the current station to continue operating during construction.

Table 8 and Figure 8 show cost estimates for both phases of the working alternative. The component costs shown for phase I of the project are Brown and Caldwell estimates and include 10 percent for contractor's operations and profit, 10 percent mobilization/demobilization, 30 percent contingency, 8.6 percent sales tax, and 35 percent for design. The phase II costs assume additional facilities are a diversion pump station and sewer sized to provide enough additional capacity to convey the 20-year peak flow.

Table 8. Working Alternative cost estimate

	Cost (millions; ENR=7,000)
Project Phase I:	
Replace Hidden Lake PS at 5.5 mgd	3.3[a]
Parallel/Replace 6,400 ft of Boeing Creek Trunk (brings control to 2-year level)	4.0[a]
Add 0.5 MG of storage upstream of Hidden Lake PS (brings control to 4 to 5-year level)	2.8[a,b]
Add KC allied costs (assume +50%)	+50%
Phase I Total	**15.1**
Project Phase II:	
Add facilities (brings control to 20-year level; KC allied costs included)[c]	20.5
Total Project Cost:	**35.6**

a. Brown and Caldwell estimates include 10% contractors O&P, 10% mob/demob, 30% contingency, 8.6% sales tax, and 35% design and owner management. These costs assume the Hidden Lake Pump Station is replaced, not retrofitted.

b. Construction costs in the congested area downstream of the Hidden Lake Pump Station have been increased by 50% to reflect the potential difficulties of design and construction in areas with large numbers of buried utilities.

c. Assumes diversion pump station and sewer sized to bring control to 20-year level with no I/I reduction, and a 7% increase in I/I per decade for 3 decades through 2030.

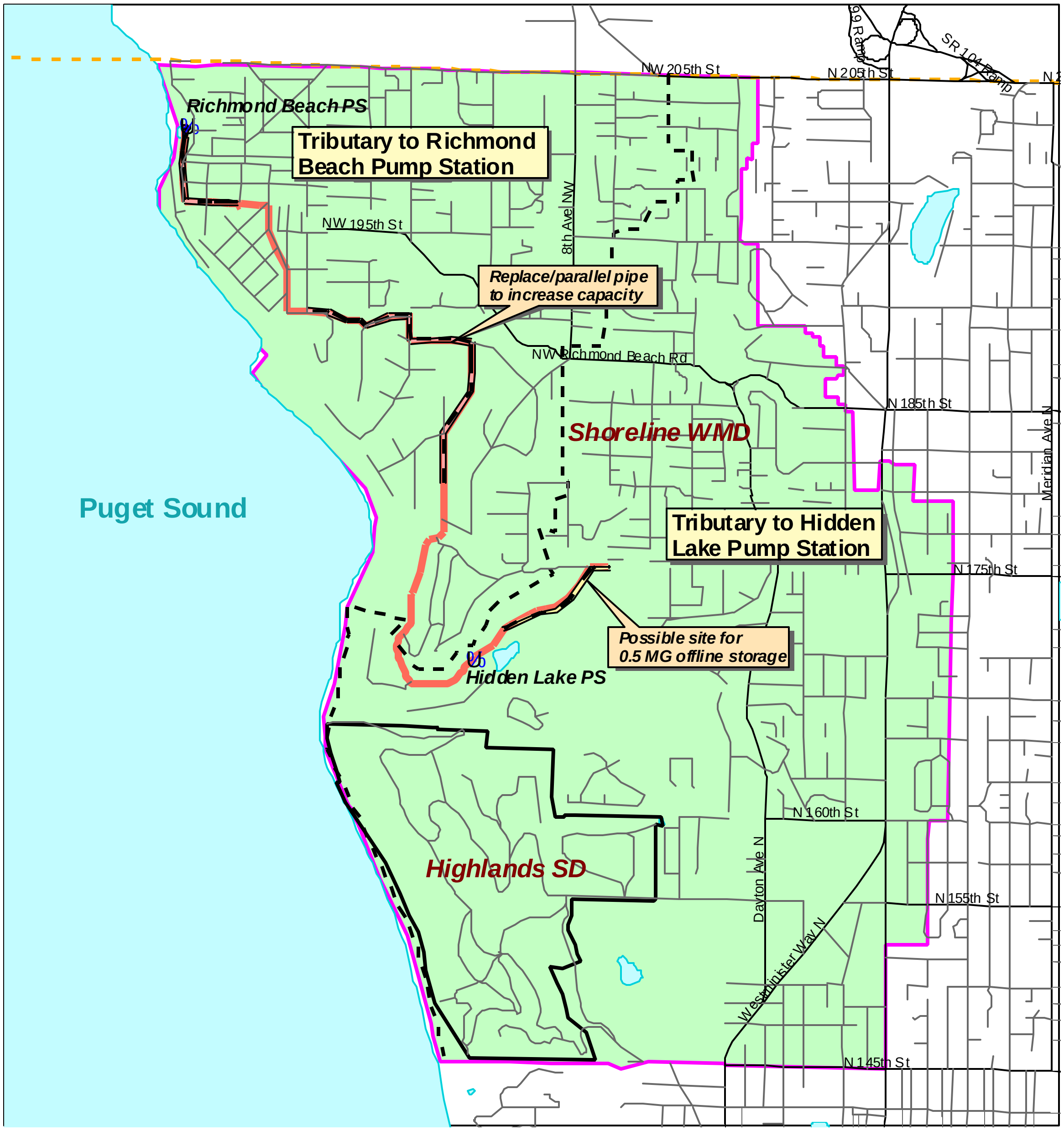

Figure 7: Working Alternative Phase I

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Legend
- Off-line storage pipe
- KC Pump Stations
- Sections to Replace/Parallel
- County Boundary
- Boeing Creek Trunk
- Hidden LK Service Area

0.1 0 0.1 0.2 0.3 Miles

May 11, 2000

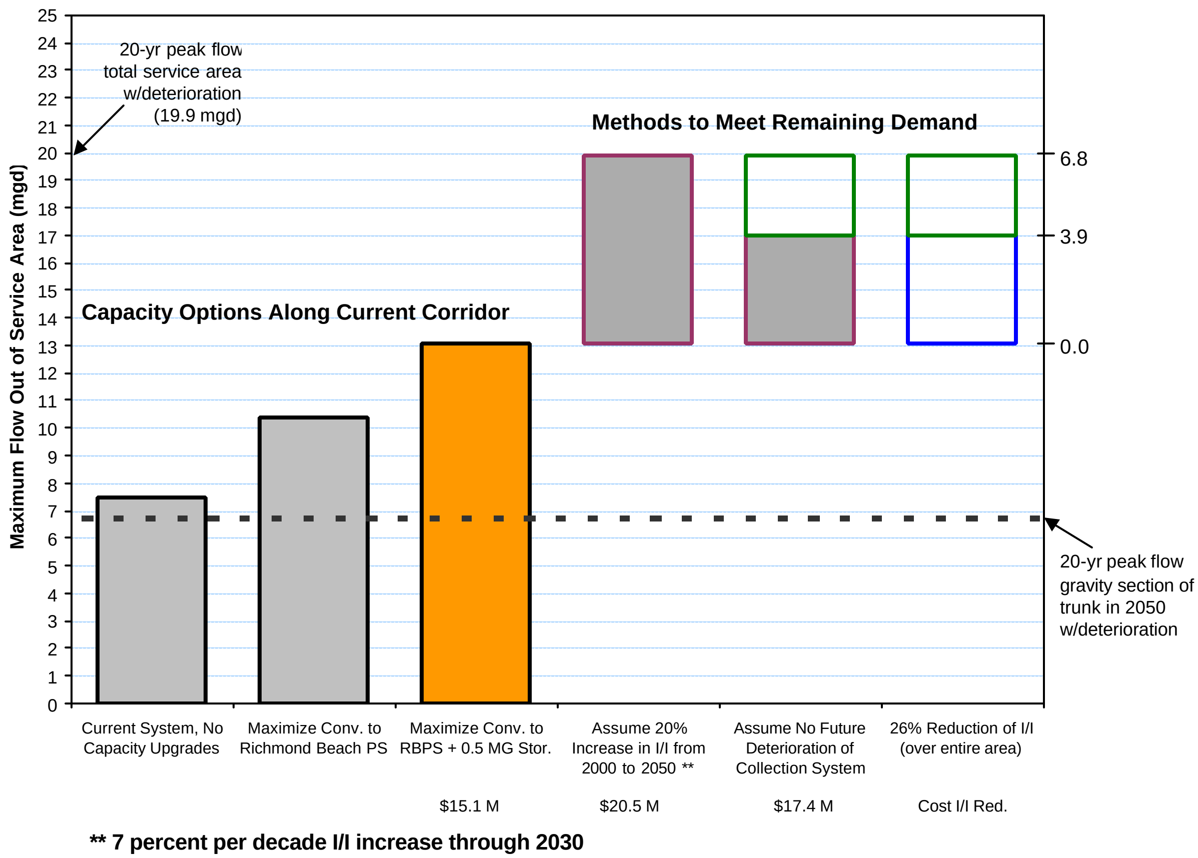

Figure 8. Distribution of costs for interim and future facilities upgrades in the Service Area